Yoruba
Basics

• Yoruba is a three-tone system.

lú ‘to mix together,’ ilú ‘city,’
lu ‘to perforate,’ ilu ‘perforator,’
lù ‘to beat,’  ilù ‘drum.’

• Tone-spreading leads to contours for HLHL sequences:

Má yò mí rà wé = [máyômí râwě]

H L H L H

• Downstep has been reported in several studies, as has downdrift (declination) across sequences of L tones.
Questions and Goals

• Yoruba claimed to have automatic downstep: progressive lowering of H tones after L.

• Is there evidence for downstep, as opposed to declination or downdrift of tone levels, which are not conditioned by tone sequence.

• How does downstep interact with H scaling. It has been claimed that H tones raise before L?

• How much “look-ahead” is there, setting the levels of initial H based on the number of down steps that will be encountered in the utterance.
Experiment 1

Materials: HL sequences of different lengths, beginning either with H or L

- Do H tone sequences show downstep effects? ✔
- Do L tone sequences show downstep effects? less clear, for some speakers—TJ in particular—in shorter sequences
- Does a sentence-initial L tone downstep a following H tone? ✗
- Are initial H tones scaled higher as the number of downsteps increases? ✗
- Does the size of the downstep interval decrease as the number of downsteps increases? ✗
- Do final H tones drop to lower values in sentences with more downsteps? small effect only for TJ
- Are later H tones reset to higher values in sentences with more downsteps? ✔ main strategy used to economize pitch space by all subjects.

![Graphs showing downstep patterns][1]

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[1]: https://example.com/graphs.png
With each increase in length, from a value of about 81 Hz in the shortest sentences to about 74 Hz in the longest ones (\(y = C_0 + 0.013x + 84.198\); \(r^2 = 0.821; p = 0.0019\)). The correlation remains significant if we use the number of effectively downstepped H tones (thus excluding any reset H tones) as the independent variable (\(y = C_0 + 1.672x + 82.18\); \(r^2 = 0.431; p = 0.0057\)). For the other speakers, there is no significant correlation between sentence length and \(H_f\).

Does the size of the downstep interval decrease as the number of downsteps increases? Again, Table 1 shows that this is not the case; scanning the values of the lowering interval \(H_1/C_0 - H_2\) from left to right across Table 1, we see that they do not steadily decrease as sentences become longer, for any speaker. Regression analysis confirms the lack of any significant effect.

Do final H tones drop to lower values in sentences with more downsteps? Table 1 shows an effect of sentence length on final H tone (\(H_f\)) values only for speaker TJ, and a minimal one at that. Regression analysis shows that the values of TJ's final H tones tend to drop by roughly 1 Hz.
Experiment 2

- Is declining ramp of H in expt 1 due to downstep or overall declination (downdrift) of H tones?
  - H shows much steeper decline in HL sequences.
  - First H is much higher in HL sequences than all-H. Due to H-raising before L.
  - L shows similar decline to expt 1, so effects there are likely not due to downstep.

Materials: All-H, all-L sequences of different lengths
4.1. Corpus design
The test sentences used in this experiment fell into three sets: all-H sentences, all-L sentences, and mixed-HL sentences similar to those used in Experiment 1. These sentences had a syntactic structure similar to those used in the earlier experiment. There were three length conditions in each set: (a) long, (b) medium, and (c) short. The test sequences were placed at the beginning of carrier sentences to absorb any final lowering effects. The sentences used in this experiment are listed in Appendix B. All sentences were read by TJ and FA and recorded and analyzed as described earlier.

4.2. Results
Fig. 5 overlays the graphs of mixed-HL sentences with those of the all-H and all-L sentences (tones of the sentence-final carrier frames are omitted here and in later figures). Graphs for TJ are shown on the left and those for FA on the right. Sentences are presented from shortest (a) to

Pattern is different than Akan, particularly for FA, where the downtrend in H was pretty much the same in all-H and H-L
Experiment 3

- Patterns of declination differ across tones and across speakers. No regularity.
- FA shows substantial declination, greater for H tones
- TJ shows declination primarily for L tones,

Materials: all-M sequences, LM, MH, LMH seqs, of different lengths
• Is apparent H-raising is expt 1 actually due to lowering of all-H?
  - No, all-H is higher than MH
• Does M trigger down step of H?
  - No for TJ
  - FA shows lowering in MH but not more than in all-H
• Is M down stepped by L?
  - No, rate of decline of M in LM is comparable to decline of all-M.
  - rate of decline of L in LM is comparable to decline of all-L.
- Is H down stepped by L when a M intervenes (LMH)?
  - No. Values of all tones in LMH sequences are comparable to their values in all-H, all-M, all-L sequences
- Some possible effects for FA. H and M lower than the all-H and all-M sequences.
Summary Expts 1-3

• Downstep applies to H tones, but not to L tones, in mixed-HL sentences.

• H raising interacts with downstep to raise the values of all H tones preceding L tones.

• L tones do not downstep M tones, nor do M tones downstep H tones.

• L tones do not appear to downstep H tones at a distance, but only when adjacent to them.

• No evidence for global lowering (“total downstep”) of all-H sentences.
Experiment 4

• Materials

Set A (HHHY ...)  Set B (HMHY ...)  Set C (HLHY ...)
1. HHHH...  4. HMHH...  7. HLHH...
2. HHHM...  5. HMHM...  8. HLHM...
3. HHHL...  6. HMHL...  9. HLHL...

• Test:

• Preplanning: compare first H in 7-8 to that in 9.

• Does H-raising operate independently of downstep: H raising in 3 and 6?
Differences between the first H peak in sentence 9 and the comparable peaks in sentences 7 and 8, are given in the second and third columns of Table 3. A second prediction of the null hypothesis is that the first H tone in sentence 9 (HLHL) should have the same peak values as the last H tones in sentences 3 (HHHL) and 6 (HMHL), since none of these tones are downstepped. This prediction is also incorrect. The peak value of the first H tone in the HLHL sentence is consistently higher, this time for all four speakers and by somewhat larger margins of 5–9 Hz, than the peak H tone values of the last H tones in sentences 3 and 6. Values are given in the fourth and fifth columns of Table 3. This result again demonstrates a "long-distance" anticipation of the L tone three syllables away.

As the f0 differences here are rather small, averaging around 6 Hz, we performed a two-way ANOVA on these data to detect interactions of the first H tone (H₁) with tone Y as well as with the immediately following tone X in HXHₐ sentences at points a; b; and c:

An interaction of

Evidence for independence of H raising

\[ Y \text{O. Laniran, G.N. Clements / Journal of Phonetics (2013)} \]
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As the f0 differences here are rather small, averaging around 6 Hz, we performed a two-way ANOVA on these data to detect interactions of the first H tone \( H_1 \) with tone \( Y \) as well as with the immediately following tone \( X \) in HXH \( Y \) sentences at points a, b, and c:

An interaction of \( H_1 \) with \( Y \) was found for TJ and KG.

Evidence for pre-planning; Initial H in 7-8 vs 9

Evidence for pre-planning; Initial H in 9 vs Hs in 3 or 6

Effect is small, but significant for TJ and KG.
Modeling Downstep: “soft-landing” model

\[ H_n = d^{n-1}(H_1 - r) + r. \]

- \( d \) is downstep factor
- \( r \) is reference level (lowest final H)

\[ H_n = d(H_{n-1} - r) + r \]

Equivalent to iterating this DS

- Authors’ problem with this model
  - Only fits TJ
  - FA data appear consistent but not after removing effect of downdrift
  - Later spans doesn't fit

My problems

- Why is it necessary to remove the effect of downdraft? Downdrift could be like an articulator that contributes to the task of downstep.
  - Model is not implemented formally/dynamically. Process of determining where the downsteps occur is not part of system.
High-raising

- Modeled as an upstep

\[ H^+ = u(H_b - r) + r, \]

- And can be combined with downstep, as they both apply to some tones, for example in HLHL

\[ H_n = \langle u \rangle d_n^{-1}(H_b - r) + r. \]

Table 8
Predicted and observed values of the H tones in TJ’s sentences 5, 8, and 9 (observed values are parenthesized)

<table>
<thead>
<tr>
<th>Sentence</th>
<th>H1</th>
<th>H2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sentence 5 (HMMHM)</td>
<td>99.5 (99.5)</td>
<td>99.5 (100.1)</td>
</tr>
<tr>
<td>Sentence 8 (HLHM)</td>
<td>111.1 (110.6)</td>
<td>94.1 (90.5)</td>
</tr>
<tr>
<td>Sentence 9 (HLHL)</td>
<td>111.1 (115.9)</td>
<td>102.7 (106.5)</td>
</tr>
</tbody>
</table>
Reset patterns: F0 of successive resets

Table 9
Resetting patterns in the mixed-HL sentences of Experiment 1

<table>
<thead>
<tr>
<th></th>
<th>TJ</th>
<th></th>
<th>FA</th>
<th></th>
<th>KG</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L-in</td>
<td>H-in</td>
<td>pooled</td>
<td>L-in</td>
<td>H-in</td>
<td>pooled</td>
</tr>
<tr>
<td>H₁</td>
<td>102.7</td>
<td>100.5</td>
<td>101.6</td>
<td>211.2</td>
<td>223.0</td>
<td>217.1</td>
</tr>
<tr>
<td>H₂₁</td>
<td>90.0</td>
<td>90.4</td>
<td>90.2</td>
<td>175.7</td>
<td>181.9</td>
<td>178.8</td>
</tr>
<tr>
<td>H₂₂</td>
<td>85.1</td>
<td>86.7</td>
<td>85.9</td>
<td>181.0</td>
<td>176.5</td>
<td>178.3</td>
</tr>
<tr>
<td>H₂₃</td>
<td>—</td>
<td>83.1</td>
<td>83.1</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>H₃₁</td>
<td>—</td>
<td>112.9</td>
<td>112.9</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>H₃₂</td>
<td>—</td>
<td>175.7</td>
<td>175.7</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>H₃₃</td>
<td>—</td>
<td>211.2</td>
<td>211.2</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Values are averages in Hz over pooled H- and L-initial sentences (d)–(h). H₁ = first H tone, Hₙₙ = nth reset H tone. Only three values are given for FA, who normally reset only twice in our data.

\[
H_{r\,n} = d'\left(H_{r\,n-1} - r\right) + r
\]

\[
d' = H_{r\,1} - r / H_{\text{in}} - r.
\]

- Problems:
- Regularity of divergence
- Maybe one step down and then downdrift, particularly for FA
- Later spans doesn't fit
- Pragmatic and discourse level
- Variability

What kind of dynamical model would actually produce resets??
Why does a language have both downstep and H-raising

- Conspire to keep H out of M range, while still allowing the “terracing” that down step provides.
- My problems with this
- This conspiracy is not actually part of the models.
- This argument refers to function, but what is the function of downstep?